Jurnal Serambi Engineering Volume XI, No.1, Januari 2026 Hal 17023 - 17035 p-ISSN : 2528-3561 e-ISSN : 2541-1934

Production Optimization Analysis Based on Effective Working Hour of Mobile Crusher Unit 02: Case Study in PT Mifa Bersaudara, West Aceh

Deea Rizki Oziana*, Syafitri Amanda, Nurul Aflah, Pocut Nurul Alam, Nurul Kamal

Mining Engineering Department, Universitas Syiah Kuala, Banda Aceh
***Corresponding author**: deearizki.oziana@usk.ac.id

Received: December 17, 2025 Approved: December 27, 2025

Abstract
PT Mifa Bersaudara is a coal mining company located in Meureubo, West Aceh, Indonesia. This study evaluates and optimizes the Effective Working Hours (EWH) of Mobile Crusher 02 (MC02), one of the key units in the coal crushing process. The primary constraint identified is the inability to achieve production targets due to excessive downtime, particularly standby time and equipment breakdowns, which significantly reduce operational efficiency. A quantitative descriptive approach was applied using primary field observations and secondary production data from May to June 2025. The analysis focused on downtime components, effective working hours, and equipment availability based on Mechanical Availability (MA), Physical Availability (PA), Utilization of Availability (UA), and Effective Utilization (EU). Results indicate that MC02 operated for an average of only 7 effective working hours out of 10.05 available hours, reflecting an efficiency level of 69.65%. Standby time accounted for the largest portion of downtime at 141.86 hours. Following a proposed operational improvement scenario aimed at reducing delays, overall efficiency increased, and production rose from 128,505 tons to 168,864 tons, achieving 112% of the targeted output. These findings demonstrate that improving EWH has a direct and significant impact on crusher productivity and provides a foundation for future operational optimization in the coal processing system.
Keywords: *effective working hours, production optimization, mobile crusher 02, crusher performance, production capacity*

Abstrak
PT Mifa Bersaudara merupakan perusahaan pertambangan batubara yang beroperasi di Kecamatan Meureubo, Kabupaten Aceh Barat. Penelitian ini bertujuan mengevaluasi dan mengoptimalkan *Effective Working Hours* (EWH) pada unit Mobile Crusher 02 (MC02), yang merupakan peralatan utama dalam proses peremukan batubara. Permasalahan utama yang diidentifikasi adalah tidak tercapainya target produksi akibat tingginya waktu hambatan, khususnya *standby time* dan *breakdown*, yang menurunkan efisiensi operasional secara signifikan. Penelitian menggunakan metode deskriptif kuantitatif dengan data primer hasil observasi lapangan serta data sekunder dari laporan produksi Mei hingga Juni 2025. Analisis difokuskan pada waktu hambatan, jam kerja efektif, dan ketersediaan alat berdasarkan indikator *Mechanical Availability* (MA), *Physical Availability* (PA), *Utilization of Availability* (UA) dan *Effective Utilization* (EU). Hasil penelitian menunjukkan MC02 hanya mencapai jam kerja efektif rata-rata 7 jam dari 10,05 jam tersedia, dengan tingkat efisiensi sebesar 69,65%. Hambatan terbesar berasal dari *standby time* sebesar 141,86 jam. Setelah dilakukan tindakan perbaikan untuk mengurangi hambatan, efisiensi operasional meningkat dan produksi naik dari 128.505 ton menjadi 168.864 ton, mencapai 112% dari target. Temuan ini menunjukkan bahwa peningkatan EWH berdampak langsung pada peningkatan produktivitas crusher dan dapat menjadi dasar optimasi operasional pada kegiatan pengolahan batubara.
Kata Kunci: *efektivitas waktu kerja, optimalisasi produksi, mobile crusher 02, kinerja crusher, kapasitas produksi*

1. Introduction

Large-scale coal production in Indonesia has expanded significantly since the late 1980s and has subsequently positioned the country as one of the world's largest coal producers and leading exporter of thermal coal [1], [2], [3]. Also, coal is the dominant Indonesian primary energy mix, accounting for 40.37% of national energy consumption in 2024 [4]. Data from the Ministry of Energy and Mineral Resources (ESDM) show that national coal output reached a record 836 million tonnes in 2024, with more than half exported to major Asian markets such as China [3], [4], [5]. This scale of production requires coal mining companies to maintain reliable, efficient, and continuous operations to meet contractual supply commitments.

Open-pit coal mining operations in Indonesia commonly utilize a semi-continuous material flow system involving excavators, haul trucks, crushing stations, and conveyor belts [6]. In this system, run-of-mine (ROM) coal is hauled to crushing stations, where it undergoes size reduction before being transported to stockpiles or processing facilities via conveyor systems. Because crushers function as the primary chokepoint in this production chain, their performance strongly influences whether daily and monthly production targets are achieved [7], [8].

One of the persistent challenges in mining operations is the effective utilization of the machinery owned and operated by a mining company, including key processing units such as crushers [9], [10]. A crusher is a machine specifically designed to reduce materials into smaller pieces [11]. A crusher's design capacity does not guarantee equivalent field output because actual productivity depends on availability, utilization, and the age of equipment [12], [13]. Consequently, one of the primary methods to evaluate machine efficiency is to analyze the Effective Working Hours (EWH), defined as the proportion of calendar time during which the equipment is in productive operation and not in downtime or delays [14], [15].

In Indonesian mining operations, mechanical efficiency of heavy equipment is commonly assessed using a set of time-based: namely Mechanical Availability (MA), Physical Availability (PA), Use (Utilization) of Availability (UA), and Effective Utilization (EU). These metrics collectively describe the readiness, actual usage, and overall effectiveness of mining equipment [16], [17]. Research highlights the significance of EWH; for instance, [14] demonstrated that reducing the frequency of mine halting operations significantly boosts overall mining efficiency, while [15] used a formal Use Case Modelling (UCM) approach to ensure that automated equipment meets stringent safety and efficiency requirements, thereby improving the quality of the effective working time.

These time-based indicators provide a structured framework for assessing the performance of mining equipment. Mechanical Availability (MA) describes the intrinsic reliability and maintainability of a unit, representing the proportion of scheduled time in which the equipment is mechanically capable of operating without breakdowns. Physical Availability (PA) extends this concept by incorporating organizational and management-related delays, thereby reflecting the total time the equipment is ready for use under real operating conditions [16], [17]. The Utilization of Availability (UA) measures the extent to which this available time is actually used for productive work, indicating the effectiveness of operational planning and field execution. Effective Utilization (EU) serves as the summary metric that captures the percentage of total scheduled time during which the equipment is truly productive, integrating both availability and utilization components [17]. Because Effective Working Hours (EWH) represent the actual productive time achieved within the equipment's operating schedule, EWH is directly determined by these availability (MA and PA) and utilization (UA and EU) indicators. Higher EWH therefore signifies that the equipment is highly available, efficiently utilized, and supported by proper maintenance and scheduling practices [13], [16], [17].

Although previous studies have analyzed equipment availability, utilization, and productivity in various mining operations [14], [15], [17], limited research has focused specifically on site-level, crusher-focused evaluations using EWH as the primary performance measure, particularly within the context of Indonesian coal mining operations.

To address this gap, this study evaluates the Effective Working Hours (EWH) of the newly acquired Mobile Crusher 02 (MC02) at PT Mifa Bersaudara, a coal mining company located in West Aceh, Indonesia. MC02 represents a significant capital investment and plays a central role in the company's coal processing system. Therefore, maximizing its effective operating time is essential for ensuring production continuity and meeting planned output. This study analyzes downtime patterns, equipment availability indicators (MA, PA, UA, EU), and their relationship with crusher performance during the May–June 2025 operational period. Furthermore, it develops a proposed optimization scenario to demonstrate how reducing avoidable delays could increase EWH and improve production outcomes. The insights gained provide a technical basis for improving operational practices and enhancing coal production efficiency at PT Mifa Bersaudara and similar operations.

The observation period of May–June 2025 was selected to represent a complete operational cycle, encompassing weekdays, weekends, and Friday shifts with extended breaks, thereby capturing typical variations in daily crusher operations. Previous studies on mining equipment performance have shown that short-term operational datasets spanning several weeks are sufficient to evaluate equipment utilization, availability, and effective working hours at the unit level, provided that operations are conducted under stable conditions [13], [14]. During the observation period, mining and hauling activities were carried out without significant external disruptions, making the data representative of normal operating conditions.

Internal production records indicate that prior to the observation period, MC02 had not consistently achieved its planned production targets. Recurring issues related to standby time, material supply interruptions, and coordination between hauling and crushing operations were observed in earlier periods. These conditions motivated the selection of MC02 as the focus of this study and underscore the need for an Effective Working Hours (EWH)–based evaluation to identify operational constraints and improvement opportunities.

2. Material and Methods

Study Area

This research was carried out at the operational site of PT Mifa Bersaudara, located in Sumber Batu Village, Meurebo District, West Aceh Regency, Aceh Province, Indonesia. PT Mifa Bersaudara operates within a concession area of approximately 3,134 hectares, supported by a valid Production Operation Mining Business License (IUP-OP). The site is accessible by a 4–5 hour road trip from Banda Aceh to Meulaboh, followed by an additional 20-minute drive to the coal processing and crushing facilities located in the Peunaga area. The study specifically focused on the operational activities of Mobile Crusher 02 (MC02) as part of the company's Coal Crushing Plant (CCP).

Research Data

This study employed both primary and secondary data. Primary data were collected through direct field observations during MC02 operation over 30 consecutive working days. Observations were conducted during the day shift (07:00–19:00 WIB), corresponding to the crusher's main production period. The recorded parameters included: equipment operating time, standby duration (non-operational but not under repair), breakdown duration (equipment failures requiring repair), and actual daily production output. In addition, field documentation was carried out to ensure the validity of the operational conditions during the research period.

Secondary data were obtained from the internal records of PT Mifa Bersaudara, including daily and monthly production reports, operational scheduling records, equipment availability data, and maintenance documents. These data were used to validate observational findings and support analytical calculations.

Instruments and Data Collection Tools

Data collection employed the following tools and instruments:

- Operational log sheets for recording hourly performance indicators,
- Crusher production records generated by the Coal Crushing Plant (CCP),
- Maintenance logs documenting breakdown causes and duration,
- Spreadsheet and statistical software (Microsoft Excel) for data tabulation and analysis.

These instruments ensured systematic and traceable measurement of the equipment's operating conditions.

Research Design and Procedure

The research was conducted through a structured sequence beginning with a preliminary review of production targets, crusher specifications, and operational policies to establish baseline conditions and performance expectations. This was followed by systematic field observations in which operating time, breakdown occurrences, and standby periods were recorded throughout each day shift. To ensure data reliability, all primary observations were subsequently verified by cross-checking against Coal Crushing Plant (CCP) production reports and maintenance documentation. The collected time elements were then processed and classified into operating, standby, and breakdown categories, forming the basis for a detailed assessment of the crusher's operational behavior.

Following data classification, performance calculations were carried out using standard mining equipment efficiency indicators, namely Mechanical Availability (MA), Physical Availability (PA), Utilization of Availability (UA), and Effective Utilization (EU). MA was used to determine the proportion of scheduled time during which the crusher was mechanically functional, while PA incorporated both mechanical readiness and organizational delays to represent the total time the unit was available for operation. UA measured the extent to which the available time was actually utilized for productive work, and EU expressed the percentage of total scheduled time that resulted in effective operation. These indicators collectively formed the analytical framework for calculating the Effective Working Hours (EWH) and identifying operational bottlenecks. The resulting performance values were compared with company operational standards and production targets to evaluate whether MC02 operated within expected thresholds and to identify the key factors influencing production underachievement.

The delay-reduction values in Table 6 represent simulation-based estimates derived from root-cause analysis, historical performance data, and discussions with site personnel. It reflects potential reductions that could be achieved if the proposed operational improvements were consistently implemented.

Operational measurements were conducted continuously during crusher operation throughout each observed day shift. Data recording was performed in real time using operational log sheets, including time stamps recorded for operating, standby, and breakdown conditions. Each shift therefore represents one complete continuous observation cycle, rather than intermittent sampling. Daily measurements were subsequently validated using Coal Crushing Plant (CCP) production reports and maintenance logs to ensure data consistency and accuracy.

Field observations were limited to the day shift (07:00–19:00 WIB) due to company safety regulations and access restrictions that prohibit direct observation during night shifts. The day shift was selected because it constitutes the primary production period, during which hauling activities, material feeding, and crusher operation are fully staffed and operate under stable conditions. Although MC02 operates on a 24-hour basis, operational procedures, equipment configuration, and production targets are consistent across shifts. Therefore, the day-shift data are considered representative for evaluating unit-level operational performance, particularly in terms of Effective Working Hours (EWH), availability, and utilization.

3. Results and Discussion

Coal Crushing Plant (CCP) at PT Mifa Bersaudara

PT Mifa Bersaudara has five crusher units, namely Fixed Crusher 01 (FC01), Fixed Crusher 02 (FC02), Fixed Crusher 03 (FC03), Mobile Crusher 01 (MC01), and Mobile Crusher 02 (MC02). These five crusher units play a role in the size-reduction process of coal material that is transported directly from Pit B to the Run of Mine (ROM) stockpile or directly to the Coal Crushing Plant (CCP). The size reduction process produces two types of final products: 100 mm lumpy coal and 50 mm fine coal.

Crushing is performed in two stages: primary crushing and secondary crushing.FC01, FC02, and FC03 use single-roll primary crushers, while MC01 and MC02 employ double roll crushers. All units utilize double roll crushers at the secondary stage, supported by chain feeder systems. Based on design specifications, FC01, FC02, FC03, MC01, and MC02 have respective capacities of 750, 450, 1,000, 350, and 500 tons per hour. This study specifically focuses on MC02, which has a nominal capacity of 500 tons/hour.

Working Days and Working Hours

The operational activities of the crushing plant at PT Mifa Bersaudara runs daily, from Monday to Sunday. In this study, data collection was focused on the day shift (07:00–19:00 WIB), with several specific time allocations. The shift structure includes P2H/P5M safety inspections, scheduled breaks, prayer times, and shift changes. **Tables 1** and **2** summarize the distribution of working hours for each day and specifically on Friday.

Table 1. Distribution of Day Shift Working Hours, Monday–Sunday (Except Friday)

Working Hours	Description	Duration (Hours)
07.00 - 07.30	P2H/P5M	0.5
07.30 - 12.30	Working Hours	5
12.30 - 13.00	Break Time	0.5
13.00 - 16.15	Working Hours	3.25
16.15 - 16.30	Praying	0.25
16.30 - 18.30	Working Hours	2
18.30 - 19.00	Change Shift	0.5
Total		12

Source: PT. Mifa Bersaudara (2025)

Table 2. Distribution of Day Shift Working Hours on Friday

Working Hours	Description	Duration (Hours)
07.00 - 07.30	P2H/P5M	0.5
07.30 - 12.30	Working Hours	4.5
12.30 - 13.00	Break Time	2

Working Hours	Description	Duration (Hours)
13.00 - 16.15	Working Hours	2.25
16.15 - 16.30	Praying	0.25
16.30 - 18.30	Working Hours	2
18.30 - 19.00	Change Shift	0.5
Total		12

Source: PT. Mifa Bersaudara (2025)

Based on the presented data in **Table 1** and **2**, the effective working hours (excluding breaks and shift transitions) amount to 10.25 hours for regular days and 8.75 hours on Fridays, due to the extended break period on Friday. Averaged over the 30-day observation period, the available effective time for one day shift was 10.05 hours. This figure serves as the basis for evaluating working time efficiency and production performance.

The allocation of 0.5 hours for P2H/P5M activities reflects standard safety inspection and briefing practices implemented by PT Mifa Bersaudara and is consistent with Indonesian mining safety regulations, particularly the Minister of Energy and Mineral Resources Regulation concerning the Implementation of Mining Safety Management Systems (SMKP Minerba) and occupational safety requirements for heavy equipment operation. This duration includes pre-operational equipment inspection (P2H), safety briefing (P5M), job assignment, and confirmation of operational readiness before production commences. Although they reduce available production time, P2H/P5M activities are considered non-avoidable and are therefore excluded from effective working hours calculations. Similarly, scheduled break and prayer periods are regulated by company policy and labor regulations, and their durations are proportional to the total 12-hour shift length. As such, these time allocations are treated as fixed operational constraints rather than inefficiencies.

Work Delay and Effective Working Hours

Work delays are conditions in which the equipment system is unable to operate optimally despite being scheduled to run. In MC02 operations, such delays generally occur in the form of standby time and breakdown time. Standby time is generally caused by external operational factors, such as delays in material supply from the mining front, queues of hauling units during dumping, stockpile space constraints, or power supply disturbance. In contrast, breakdown time arises from internal technical problems in the crusher system that require inspection or repair before the unit can resume operation. Both delay types directly reduce the effective operating time of the crusher, thereby affecting the productivity achieved. The total duration of work delays recorded during the observation period is presented in Table 3.

Table 3. Total Work Delays of Mobile Crusher Unit 02 (MC02)

Parameter		MC02 Actual Hours
Operation	Crushing	210
Total (Hours)		210
Standby	P2H/P5M	6.22
	Waiting Material	3.40
	Waiting Unit	55.12
	Cleaning Area	0.65
	Rest Time	12.98
	Praying	11.10
	Friday Prayer	6
	Refueling Unit Support	1.52
	PLN Problem (Power Outage)	3.87
	Stockpile Full Space	20.77
	Change Shift	17.50
	Block Chute Conveyor 03	0.45
	Blocked Material in Primary Crusher	2.28
Total (Hours)		141.86
Breakdown	Conveyor 03 Radial Motor Burnt	4.42
	Primary Crusher Chute Leak Repair	1.67
	Radial Stacker Trip	0.88
	Chain Feeder Trip	0.23
	Conveyor Trip	1.40
Total (Hours)		8.6

Based on the data presented in **Table 3**, the total delay time recorded for MC02 during the 30-day observation period (Day Shift) reached 150.46 hours, which is equivalent to an average of approximately 5 hours of delay per shift (Day Shift). Using Equation (1), the average effective working hours (We) obtained for MC02 are:

$$We = Wt - Wh \quad \text{Eq. (1)}$$
$$We = 12\ hours/Day\ Shift - 5\ hours/Day\ Shift$$
$$We = 7\ hours/Day\ Shift$$

Based on these calculations, the average effective working time of MC02 during the 30-day research period, from 28 May to 30 June 2025 was 7 hours per Day Shift. When compared to the average available working time of 10.05 hours, the working time efficiency (E) of the crusher is:

$$E = \frac{We}{Wt}\ x\ 100\% \quad \text{Eq. (2)}$$
$$E = \frac{7\ hours}{10.05\ hours}\ x\ 100\%$$
$$E = 69.65\%$$

This efficiency level of 69.65% indicates that nearly one-third of the available time is lost due to operational delays. Similar findings have been reported in previous studies, where standby and organizational delays were identified as major contributors to lost effective working time and reduced system performance [9], [10], [13]. In particular, Moraes et al. [14] demonstrated that a substantial gap between scheduled shift duration and active working time significantly decreases overall mining efficiency. Samamba et al [13] emphasized that improving effective utilization of equipment hours can yield substantial gains in production without additional capital investment. Compared with these studies, the EWH of MC02 can be considered suboptimal and indicates considerable room for operational improvement.

Crusher Production and Productivity

The productivity of a crusher unit is determined by the volume of coal fed into the hopper by hauling units (trucks) during effective operating hours. According to company planning data, with a nominal capacity of 500 tons/hour and an average available effective working time of 10.05 hours per shift, the targeted production for the 30-day research period (28 May to 30 June 2025) was 150,750 tons, or 5,025 tons per shift.

However, field observations show that, due to delay, MC02 only achieved 7 effective operating hours per shift, approximately 3 hours less than planned EWH. The difference is essential in assessing the extent to which the production target can be achieved based on actual working hours. The production data in Table 4 reflect this discrepancy: the total actual production during the research period was 128,505 tons, compared to the planned 150,750 tons. Using equation (3), the production achievement could be calculated as follows:

$$Production\ Target\ Achievement = \frac{PA}{PT}\ x\ 100\% \quad \text{Eq. (3)}$$
$$Production\ Target\ Achievement = \frac{128,505}{150,750}\ x\ 100\%$$

$$Production\ Target\ Achievement = 85\%\ (Day\ Shift)$$

The shortfall of 22,245 tons over 30 days demonstrates that the production targets were not met and that the crusher only achieves 85% of the production. Some shift days achieved over 100% of the target, while others fell far below, indicating high variability in operational conditions, especially in terms of material supply, upstream dispatching, and temporary stoppages. Similar findings were reported by Pratama et al. [7], who showed that irregular feeding and frequent interruptions in coal processing lines led to significant deviations from monthly production targets. In line with Kyekyere et al. [8], such variability not only reduces average output but can also increase the frequency of stress-related equipment failures in the long term.

From a practical perspective, these results suggest that the gap between planning (based on nominal capacity and ideal EWH) and actual field performance is primarily due to operational constraints rather than inherent technical limitations of the crusher. Therefore, improving production is more likely to depend on increasing EWH and stabilizing material flow than on upgrading crusher capacity.

Table 4. Production of Mobile Crusher Unit 02 (MC02) on 28 May – 30 June 2025

Date	Production Target (Tons)	Researcher's Analyzed Production (Tons)	Production Achievement (%)
28/5/2025	5025	4765	95%
29/5/2025	5025	4885	97%
30/5/2025	5025	3970	79%
31/5/2025	5025	3360	67%
1/6/2025	5025	4425	88%
2/6/2025	5025	4256	85%
3/6/2025	5025	2169	43%
4/6/2025	5025	4857	97%
5/6/2025	5025	2903	58%
7/6/2025	5025	2227	44%
9/6/2025	5025	3726	74%
10/6/2025	5025	3568	71%
11/6/2025	5025	5713	114%
12/6/2025	5025	4206	84%
13/6/2025	5025	4237	84%
14/6/2025	5025	4537	90%
15/6/2025	5025	4642	92%
16/6/2025	5025	5724	105%
17/6/2025	5025	4672	93%
18/6/2025	5025	4783	95%
19/6/2025	5025	4293	85%
20/6/2025	5025	4082	81%
21/6/2025	5025	5466	109%
22/6/2025	5025	5017	100%
23/6/2025	5025	4642	92%
24/6/2025	5025	4753	95%
26/6/2025	5025	4416	88%
27/6/2025	5025	4381	87%
28/6/2025	5025	5209	104%
30/6/2025	5025	3071	61%
Total	150,750	128,505	85%

Daily production variability demonstrates a clear operational association with standby-related delays. Days characterized by prolonged waiting-unit, waiting-material, or stockpile full-space conditions consistently exhibited reduced effective working hours and lower production output. For example, on 3 June 2025, production reached only 43% of the target, coinciding with extended waiting-unit delays and stockpile congestion that limited crusher feed continuity. Similar operational patterns were observed on other low-production days, indicating that standby-related delays play a dominant role in reducing daily production performance.

In contrast, production levels exceeding 100% of the daily target as observed on 11, 16, and 21 June 2025 were achieved under stable operational conditions rather than through overtime or extended working hours. On these days, material supply to the crusher was continuous, standby-related delays were minimal, and stockpile capacity constraints did not occur. As a result, MC02 was able to operate consistently near its actual operating capacity throughout the scheduled shift.

Although the nominal design capacity of MC02 is 500 tons per hour, company production records indicate that the crusher can achieve higher short-term throughput under favorable material and operational conditions. When effective working hours approach their optimal value and feed continuity is maintained, daily production can therefore exceed the planned target. These high-production days demonstrate that the crusher system is technically capable of meeting or surpassing production targets, provided that operational delays are effectively controlled. This contrast between low-production and high-production days further reinforces that improving operational continuity and reducing standby delays offers greater production gains than increasing nominal equipment capacity.

Equipment Availability Assessment of the Crusher Unit

The availability performance of MC02 was evaluated using four key indicators: Mechanical Availability (MA), Physical Availability (PA), Use of Availability (UA), and Effective Utilization (EU). Each indicator is used to assess different aspects, namely technical readiness, physical availability, utilization level, and the overall effectiveness of the equipment in generating production. The calculation was performed using formulas as follows:

$$PA = \frac{W+S}{W+S+R} \times 100\% \quad \text{Eq. (4)}$$
$$MA = \frac{W}{W+R} \times 100\% \quad \text{Eq. (5)}$$
$$UA = \frac{W}{W+S} \times 100\% \quad \text{Eq. (6)}$$
$$EU = \frac{W}{W+R+S} \times 100\% \quad \text{Eq. (7)}$$

Where:
W = crushing time (hours)
R = Repair time (hours)
S = Standby time (hours)

The results, summarized in **Table 5**, show that MA and PA are 96.07% and 97.61% respectively. The numbers indicate that the crusher is mechanically reliable and generally ready for operation during most of the scheduled time.

Table 5. Equipment Availability of Mobile Crusher Unit 02

Working Hours	**Total Hours**
Effective Working Hours	210
Standby	141.86
Breakdown	8.6
Parameters	**(%)**
Mechanical Availability (MA)	96.07%
Physical Availability (PA)	97.61%
Use of Availability (UA)	59.68%
Effective Utilization (EU)	58.26%

In contrast, the values of UA (59.68%) and EU (58.26%) are much lower. This means that, although the crusher is available, it is not utilized effectively for productive work during a large portion of the scheduled hours. This discrepancy between high availability and low utilization is consistent with the pattern discussed earlier: the dominant delays are not caused by mechanical breakdowns (total breakdown time is relatively small at 8.6 hours) but by standby conditions such as waiting for material, stockpile congestion, or coordination issues between hauling and crushing units. Alfarizi et al. [17] also highlighted that high physical availability does not automatically translate into high production if the use of availability (UA) is constrained by poor synchronization of mining operations. Therefore, proper implementation of routine maintenance and improved operational management is required to ensure that the available working hours can be fully utilized so that production activities can run more smoothly.

When compared with previous studies on equipment effectiveness in mining, such as Samatemba et al. [13], the EU value of MC02 is relatively low and signals that the crushing system is underutilized. Earlier work at PT Mifa Bersaudara [18] and [19] showed that changes in operating methods such as ripping and double-dump strategies could significantly increase crusher productivity by improving material flow consistency and reducing unplanned idle time. The present findings corroborate those results: the main challenge is not the technical capability of the crusher, but the operational conditions that limit its utilization.

Optimization of Production Target Achievement

To improve the likelihood of achieving the planned production target for MC02, several operational enhancements are proposed to reduce avoidable delays that were identified during the research period. These delays are primarily related to material flow interruptions, hauling coordination issues, minor obstructions, and stockpile constraints. These non-productive conditions could be reduced through systematic operational adjustments. Table 6 summarizes the estimated reductions in delay duration if the proposed measures are applied.

The proposed improvement values in Table 6 were developed using a scenario-based ‘what-if’ analysis, in which avoidable delay components were systematically reduced according to operational judgement historical delay patterns, and feasible improvement measures. The resulting impacts on Effective

Working Hours (EWH), equipment utilization, and production output were then recalculated to evaluate potential performance gains. This approach is consistent with simulation-based evaluation methods commonly applied to assess alternative operational scenarios prior to field implementation [20].

Table 6. Avoidable Work Delays of Unit MC02

Parameter		Before Optimization (Hours)	After Improvement (Hours)	Deviation
Standby	Waiting Material	3.40	1.15	2.25
	Waiting Unit	55.12	13.58	41.54
	Block Chute	0.45	0.15	0.30
	Block Material in Primary Crusher	2.28	1.50	0.78
	Stockpile Full Space	20.77	9.75	11.02
Breakdown	Burnt Motor Conveyor Radial	4.42	0	4.42
	Leaking Primary Chute Repair	1.67	0	1.67
	Trip Radial Stacker	0.88	0.06	0.82
	Trip Chain Feeder	0.23	0.10	0.13
	Conveyor	1.40	0.20	1.20
Total		90.62	26.49	64.13

For waiting-material delays, improvements in hauling cycle time and the use of ROM rehandling are expected to maintain hopper feed continuity, potentially reducing delays from 3.40 hours to 1.15 hours. Waiting-unit delays, the largest contributor to total standby time, may be reduced from 55.12 to 13.58 hours through improved dispatch coordination and quicker mobilization of hauling units after breaks and shift transitions. Routine chute cleaning and improved material-flow monitoring are proposed to reduce blocked-chute delays from 0.45 to 0.15 hours, while grizzly maintenance and better feed-size control may decrease block-material delays from 2.28 to 1.50 hours. Similarly, enhanced stockpile management and better scheduling of hauling activities could reduce stockpile full-space delays from 20.77 to 9.75 hours.

These proposed reductions align with findings from previous research showing that optimized material flow, preventive maintenance, and tighter inter-departmental coordination significantly improve equipment utilization and production efficiency [7], [13], [17]. By reducing avoidable delays and increasing Effective Working Hours (EWH), the proposed optimization framework offers a practical pathway for MC02 to operate more consistently near its design capacity and to improve the likelihood of achieving planned production targets.

For breakdown-related delays, several corrective actions are proposed to improve mechanical reliability and reduce total downtime during similar operational periods. Damage to the radial conveyor motor which is responsible for 4.42 hours of breakdown may be fully eliminated through motor replacement, provision of a standby unit, and routine inspection of electrical and cooling systems. Leakage in the primary crusher chute, contributing 1.67 hours of downtime, can be addressed through liner replacement, reinforcement of worn joints, and scheduled chute maintenance. Radial stacker trips may be reduced from 0.88 to 0.06 hours by stabilizing power supply conditions, replacing worn transmission components, and adjusting motor protection settings. Likewise, chain-feeder trips may be minimized from 0.23 to 0.10 hours through component replacement, mechanical and electrical repairs, and improved feed-size control using optimized grizzly screening. Conveyor-related breakdowns, which account for 1.40 hours of downtime, may also be reduced to 0.20 hours by strengthening preventive-maintenance routines and enhancing early detection of belt wear or misalignment.

Proposed Operational and Performance Improvement

The proposed reduction of avoidable delays is expected to improve the operational efficiency of MC02 by increasing the amount of time available for productive work. Based on the avoidable-delay totals in Table 6, the cumulative delay during the 30-day observation period was 90.62 hours. If the optimization measures are applied, this amount could be reduced to 26.49 hours, corresponding to a potential improvement of 64.13 hours over the research period. The estimated improvement reflects the operational benefit of reducing standby and breakdown durations. Using Equation (1) and (2), the effective working hours per shift and the corresponding working-time efficiency are 9.13 hours/day and 90.8%, respectively. This represents an increase from the original 69.65% efficiency. Over 30 days, effective operating hours improved from 210.00 hours to 274.13 hours, increasing the average from 7.00 to 9.13 hours per shift.

Jurnal Serambi Engineering JSE
Volume XI, No.1, Januari 2026 Hal 17023 - 17035
p-ISSN : 2528-3561
e-ISSN : 2541-1934

These results indicate that reducing avoidable delays offers substantial potential for increasing effective operating time and improving crushing-plant performance.

Using the improved working-time estimates, the equipment-availability indicators for MC02 can be recalculated. **Table 7** presents the estimated values assuming that the proposed delay-reduction measures are implemented.

Table 7. Estimated Availability Indicators After Proposed Improvements (MC02)

Parameter	Values (%)
Mechanical Availability (MA)	99.90%
Physical Availability (PA)	99.87%
Use of Availability (UA)	76.13%
Effective Utilization (EU)	76.05%

Availability values above 85% are generally classified as good, while values between 65–85% indicate normal performance. The estimated MA and PA exceed 99%, reflecting strong mechanical readiness and minimal expected breakdown time under improved conditions. Meanwhile, UA and EU increase from below 60% to above 76%, moving MC02 into the "normal" category and demonstrating the potential operational benefit of reducing avoidable delays.

To assess the impact of improved effective working hours on production potential, a production simulation was conducted using the actual average crushing capacity obtained from company records. Based on the simulation, estimated production increases from 128,505 tons (actual production during the observation period) to 168,864 tons over 30 days, representing an improvement of 40,359 tons. This corresponds to 112% of the company's production target, whereas the baseline condition achieved only 85% of the target.

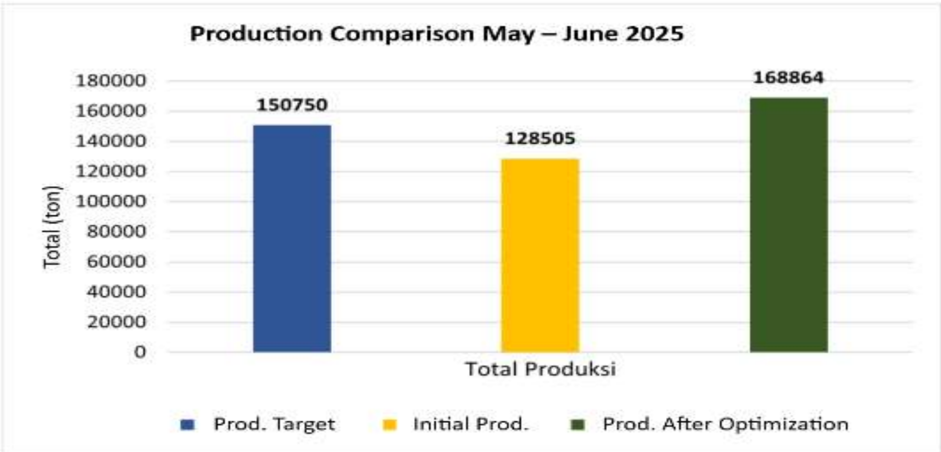

Fig. 1: Production Comparison during May to June 2025

Figure 1 illustrates the difference between target production, initial actual production, and projected production after working-time improvement. These results suggest that optimizing effective working hours through reduction of avoidable delays has a direct and substantial impact on production achievement. The estimated improvement indicates that MC02 could not only meet but exceed production targets if delay-reduction measures are implemented, reinforcing the strong relationship between operational continuity, working-time efficiency, and crusher productivity.

Sustaining improved operational performance requires more than short-term corrective actions. It depends on the consistent application of standardized operating practices and continuous performance monitoring. Previous studies have shown that preventive maintenance, clear operational procedures, and systematic evaluation of equipment utilization are essential for maintaining long-term performance improvements in mining operations [13], [17]. Routine monitoring of standby-related delays, such as waiting-unit, waiting-material, and stockpile full-space conditions, using Effective Working Hours (EWH) as a key performance indicator enables early identification of operational inefficiencies before they significantly affect production. Similar approaches based on the analysis of active and inactive working time have been successfully applied to improve operational stability and equipment utilization [14]. Furthermore, aligning production planning with realistic effective working-hour targets rather than nominal shift duration reduces the gap between planned and actual output, supporting long-term operational stability and minimizing excessive operational stress on equipment and personnel.

4. Conclusion

This study evaluated the performance of Mobile Crusher 02 (MC02) at PT Mifa Bersaudara using Effective Working Hours (EWH) and availability indicators. Over the 30-day observation period (28 May - 30 June 2025), MC02 achieved an average of 7 effective working hours per shift (day shift), equivalent to 69.65% efficiency, out of 10.05 hours available. The largest contributors to lost effective time were standby delays (141.86 hours), followed by breakdowns (8.6 hours), indicating that operational interruptions were the primary cause of reduced productivity, rather than mechanical failures.

Although technical reliability was high, with MA = 96.07% and PA = 97.61%, operational constraints such as inconsistent material supply and hauling delays significantly reduced utilization, reflected in low UA (59.68%) and EU (58.26%). Consequently, actual production reached only 128,505 tons, or 85% of the planned target.

A proposed optimization scenario demonstrates that reducing avoidable delays could increase effective working hours to 9.13 hours per shift and increase efficiency to 90.8%. Under these conditions, equipment availability improves substantially (MA 99.90%, PA 99.87%, UA 76.13%, EU 76.05%) and projected production increases to 168,864 tons (112% of the target). These findings demonstrate that improving working-time effectiveness, particularly through better material-flow coordination and tighter control of non-productive delays, is the key factor in enhancing crusher performance and achieving production targets.

Recommended Action Plan

To translate the proposed optimization into sustainable operational improvement, a phased action plan is recommended. In the short term, PT Mifa Bersaudara should prioritize daily monitoring of Effective Working Hours (EWH), Use of Availability (UA), and Effective Utilization (EU) to enable early identification of standby-related delays. In the medium term, improved coordination between hauling, crushing, and stockpile management, supported by strengthened preventive maintenance programs, is required to stabilize operational performance. In the long term, integrating EWH-based evaluation into regular production planning and management review processes will help ensure that performance improvements are sustained and aligned with achievable operational targets. Table 8 below presents a strategic roadmap outlining priority actions, implementation timelines, and responsible units to support systematic adoption of the EWH-based optimization framework at PT Mifa Bersaudara.

Table 8. Proposed Operational Improvement Roadmap for MC02

Priority	Action	Timeframe	Responsible Unit
High	Establish daily monitoring of EWH, UA, and EU as key performance indicators	Short-term (0–3 months)	Crushing Plant Supervisor
High	Improve coordination between hauling and crushing units to reduce waiting-unit and waiting-material delays	Short-term (0–3 months)	Mine Operations & Dispatch
Medium	Optimize stockpile management and hauling schedule to prevent stockpile full-space conditions	Medium-term (3–6 months)	Production Planning & Logistics
Medium	Strengthen preventive maintenance and routine inspection for crusher, conveyors, and feeders	Medium-term (3–6 months)	Maintenance Department
Low	Integrate EWH-based evaluation into monthly performance reviews and production planning	Long-term (>6 months)	Mine Management

5. Acknowledgment

Authors thank our colleagues from Universitas Syiah Kuala and PT Mifa Bersaudara who provided insight and expertise that greatly assisted the research.

6. References

[1] I. Wollff, "Coal resources, production, and use in Indonesia," in *The Coal Handbook: Towards Cleaner Coal Utilization*, 2nd ed., vol. 2, Woodhead Publishing Series in Energy, pp. 361–430, 2023.

[2] M. C. Friederich and T. van Leeuwen, "A review of the history of coal exploration, discovery and production in Indonesia: The interplay of legal framework, coal geology and exploration strategy," *International Journal of Coal Geology*, vol. 178, pp. 56–73, Jun. 2017, doi: 10.1016/j.coal.2017.04.007.

[3] H. Ilango and P. Adhiguna, *Coal Mining in Indonesia: The Paradox of Strength and Uncertainty*. Energy Shift Institute, Jun. 2025. [Online]. Available: https://energyshift.institute/wp-content/uploads/2025/06/Energy-Shift-Institute_Coal-Mining-In-Indonesia-Report-The-Paradox_202506.pdf.

[4] Ministry of Energy and Mineral Resources (ESDM), *Handbook of Energy and Economic Statistics of Indonesia 2024*. Jakarta, Indonesia: ESDM, 2024. ISSN 2538-3464. [Online]. Available: https://www.esdm.go.id/assets/media/content/content-handbook-of-energy-and-economic-statistics-of-indonesia-2024.pdf.

[5] Reuters, "Indonesia's produces record 836 mln metric tons of coal in 2024, beats target" *The Economic Times – EnergyWorld*, Feb. 3, 2025. [Online]. Available: https://energy.economictimes.indiatimes.com/news/coal/indonesias-produces-record-836-mln-metric-tons-of-coal-in-2024-beats-target/117883725.

[6] H. Kang, B. Wang, F. Gao, Y. Zhang, Z. Fan, S. Li, X. Xu, P. Chen., "Current status and prospects of coal mining science and technology in China," GeoEnergy Communications, vol. 1, p. 3, 2025, doi: 10.1007/s44421-025-00002-5.

[7] A. I. Pratama, A. Husni, and S. Gumanti, "Crusher productivity analysis in coal processing to achieve monthly production target at PT Jaksa Laksa Utama site PT BGG Lahat South Sumatra," *JHSS*, vol. 2, no. 3, pp. 310–315, Sep. 2025. Accessed: Nov. 19, 2025. [Online]. Available: https://humaniorasains.id/jhss/article/view/139.

[8] E. Kyekyere, E. O. Olakanmi, R. V. S. Prasad, B. Matshediso, T. Motimedi, A. Botes, and S. L. Pityana, "Analysis of failure characteristics of screen plates of ring hammer crusher used in coal handling applications," *Engineering Failure Analysis*, vol. 162, Art. no. 108351, Aug. 2024, doi: 10.1016/j.engfailanal.2024.108351.

[9] J. Brodny and M. Tutak, "Applying sensor-based information systems to identify unplanned downtime in mining machinery operation," *Sensors*, vol. 22, no. 6, p. 2127, 2022, doi: 10.3390/s22062127.

[10] J. Brodny, M. Tutak, and M. Michalak, "The use of the TGŚP module as a database to identify breaks in the work of mining machinery," in *Beyond Databases, Architectures and Structures. Towards Efficient Solutions for Data Analysis and Knowledge Representation (BDAS 2017)*, S. Kozielski, D. Mrozek, P. Kasprowski, B. Małysiak-Mrozek, and D. Kostrzewa, Eds. Cham, Switzerland: Springer, 2017, pp. 396–407, doi: 10.1007/978-3-319-58274-0_35.

[11] J. Gaspar, A. C. Soares, and R. F. Martins, "Analysis and prevention of wear failure in a hammer crusher used in a cement plant production line," *Engineering Failure Analysis*, vol. 182, Part A, Art. no. 110009, Dec. 2025, doi: 10.1016/j.engfailanal.2025.110009.

[12] C. N. Burt and L. Caccetta, *Equipment Selection for Mining: With Case Studies*. Cham, Switzerland: Springer, 2018, doi: 10.1007/978-3-319-76255-5.

[13] B. Samatemba, L. Zhang, and B. Besa, "Evaluating and optimizing the effectiveness of mining equipment: The case of Chibuluma South underground mine," *Journal of Cleaner Production*, vol. 252, Art. no. 119697, Apr. 2020, doi: 10.1016/j.jclepro.2019.119697.

[14] G. R. Moraes, I. Ullah, and G. de Tomi, "Determining an optimal shiftwork duration by comparative analysis of active and inactive hours in underground mining: A case study," *Mining, Metallurgy & Exploration*, vol. 41, pp. 1337–1349, 2024, doi: 10.1007/s42461-024-01003-4

[15] W. X. Tong, P. Knights, T. Phillips, M. Kizil, and M. Nehring, "Application of use case modelling to achieve safe, efficient mining equipment automation," in *Proc. 5th Int. Future Mining Conf.*, Perth, WA, Australia, Dec. 6–8, 2020. Carlton, VIC, Australia: AusIMM, 2021.

[16] Y. Indonesianto, *Pemindahan Tanah Mekanis*. Yogyakarta, Indonesia: UPN "Veteran" Yogyakarta, 2015.

[17] M. A. Alfarizi, N. Nurhakim, and R. Noorhakim, "Hubungan physical availability dan used of availability terhadap overburden removal di PT Semesta Centramas," *Jurnal HIMASAPTA*, vol. 5, no. 2, pp. 29–39, Aug. 2020, doi: 10.20527/jhs.v5i2.2338.

[18] H. Baramsyah, T. Zulfikar, N. Kamal, and M. G. Nilda, "Pengaruh penerapan metode ripping pada penambangan batubara terhadap produktivitas crushing plant (Studi kasus: PT Mifa Bersaudara, Aceh Barat)," *Jurnal Teknik Mesin Unsyiah*, vol. 8, pp. 26–33, Jun. 2020.

[19] A. Ali and M. Prieska, "Improvement produksi crusher dengan metode double dump crusher FC01 dan FC02 PT Mifa Bersaudara," in *Prosiding Temu Profesi Tahunan XXVIII PERHAPI 2019*, Indonesia, 2019, pp. 39–48.

[20] A. M. Law, *Simulation Modeling and Analysis*, 5th ed. New York, NY, USA: McGraw-Hill Education, 2015.